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ABSTRACT

The seven papers in this collection focus on effective teaching strategies for using technology, the evaluation of school technology programs, and the design and use of technology-related products. Titles of the individual papers are (1) "Student Empowerment in a High Computer-Access Environment--An Exploratory Study (ACOT Report No. 1)" (Charles Fisher); (2) "The Influence of High Computer Access on Students' Thinking: First- and Second-Year Findings (ACOT Report No. 3)" (Robert Tierney); (3) "At-Home Remediation via Technology: An Exploratory Study of a Computer Loan Program" (Gregory Sales and Jason Earle); (4) "A Case Study of a School District's Investigation of Computer-Managed Instruction" (Jason Earle and Gregory Sales); (5) "The Current Availability and Use of Computers in Science Education Grades 7-12 in Minnesota" (Frances Lawrenz, Elizabeth Thornton, and Richard Clark); (6) "A Report of an Evaluation Study of the Computer Applications Now (CAN--Computer Applications Now) Project" (Richard Kimpston and others); and (7) "Frequency and Spacing of Drill and Practice in the Learning of Verbal Information Using a Computer-Based Drill" (S. Del Marie Rysavy). Most of the papers include references. Additional resources on research in educational technology and specifications for manuscripts submitted to the Center for the Study of Educational Technology are also provided. (GL)

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Research Bulletin #2

November 1989

Evaluating the Use of Technology in Schools: What We Are Learning

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The purpose of the research bulletin, *Evaluating the Use of Technology in Schools: What We Are Learning*, is to provide educational decision-makers with empirical data for making informed decisions relative to the integration of technology. It is designed to make research results available in a timely fashion and in an easy-to-read format. The research bulletin describes the results of studies conducted by the MECC/University of Minnesota Center for the Study of Educational Technology. It also describes other technology-related studies not conducted by the Center that might be of interest to decision-makers.

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Foreword

The Center for the Study of Educational Technology is a unique partnership between MECC and the University of Minnesota College of Education. This partnership merges the practical experience and field-based success of MECC with the research expertise of the University. Founded in 1987, the Center was designed to improve the use of technology in schools. This goal is met by the Center's own research program by distributing information on research results of the Center and other institutions and by testing new models of field-based research.

Technology has been used in schools for many years but little empirically-based research judging its effectiveness has accumulated. Dr. Peggy Roblyer of Florida A & M University bluntly states: "The overwhelming conclusion that you must come to is that there is not enough [technology-related] research to make good conclusions" ("World Leaders," 1988, p. 24). This lack of empirical evidence contributes to the growing apprehension about the value of continuing or expanding support for technology-related programs.

The Center's main focus is on conducting research to help build the empirical base related to technology use in the schools. By conducting its own research program and supporting the research of University faculty members, the Center is making contributions to this body of knowledge. However, the development of a research foundation alone will not help educators and the public decide on the appropriate use of technology.

To be useful, research results must be made available to decision-makers in a timely fashion and in a format that is easy to read. Center research results are published in scholarly journals, and the Center distributes two of its own publications: *The Research Synopsis* and *The Research Bulletin*. *The Research Synopsis* is a brief summary of current research results. *The Research Bulletin* is a detailed technical description of Center studies. Both publications are designed to present Center research and research efforts of other institutions in a format that is useful to educational practitioners.

Another Center focus is on the testing of new models for conducting field-based research. These models are an attempt to address the methodological shortcomings noted by researchers such as Dr. Henry Becker of Johns Hopkins University (Becker 1987). Shortcomings include selecting student samples for the convenience of school class groupings instead of through a randomizing method, small sample sizes of typically fifty or fewer students, treatments of only a few weeks, and the lack of comparison groups to contrast to the technology-using students.

Finally, researchers and school administrators must work together to find creative solutions to the lack of school participation in technology-related research projects. The Center can facilitate discussions that address the following issues: (1) additional time and effort required by participating teachers, (2) scheduling the experimental treatment to coincide with an appropriate period in the school's curriculum, and (3) limiting unexpected school scheduling changes that can disrupt research plans.

Building a solid technology-related research base requires cooperative efforts to remove the traditional difficulties associated with field-based research.

The MECC/University of Minnesota Center encourages educators engaged in research on educational technology to share their findings and make known to the Center the kinds of information they have available for distribution.

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EFFECTIVE TEACHING STRATEGIES FOR USING TECHNOLOGY

Apple Classrooms of Tomorrow
Advanced Technology Group
Apple Computer, Inc.

ACOT Report No. 1
ERIC Report No. ED 304 100

Student Empowerment in a High Computer-Access Environment – An Exploratory Study (An Exploratory Study of the Nashville ACOT Site)

by
Charles W. Fisher
University of Northern Colorado

Background/Problem Statement

This study seeks to identify classroom conditions that affect student empowerment and validate anecdotal evidence that high computer access (HCA) promotes empowered learning in Apple Classrooms of Tomorrow (ACOT) classrooms.

In this study, "student empowerment" refers to an internal state in which students see themselves as responsible for, in control of, or the source of their own learning; "learning" refers to a process that involves some combination of thinking, watching, listening, reading, writing, speaking, or physical manipulation; and "HCA" refers to an environment in which computers are readily available for use by students and teachers.

Study Goal

To identify classroom conditions that affect student empowerment and to examine potential relationships between high computer access and student empowerment.

Methodology

This exploratory study analyzed descriptive data collected in two fourth-grade classrooms at a single school in the spring of 1988. The researcher observed for one week in a classroom with HCA and one week in a classroom without HCA. He identified indicators of student empowerment by analyzing the tasks that constitute students' schoolwork. Then he compared schoolwork in the HCA class to schoolwork in the non-HCA class.

The study seeks to explore four major hypotheses:

- HCA in the instructional environment increases student empowerment.
- Students with HCA are more likely to take initiative in shaping the tasks that compose schoolwork.
- Students with HCA are more likely to consult a variety of information sources.
- Classrooms with HCA have a greater flow of information.

Data collection consisted of observing and documenting all academic activities during the observation period. Data included extensive field notes, videotapes, recorded interviews, and assorted student materials.

The data was coded and analyzed to identify conditions that affect student empowerment as suggested by the major hypotheses.

Conclusions

The investigator identified four classroom conditions that affect the level of student empowerment:

- Task shaping (the ability to expand, modify, or in some way "shape" an assignment). As the level of student task shaping increased, so did the opportunity for student empowerment.
- Task size. As tasks increased in size, so did the opportunity for student empowerment.
- Task complexity. As tasks became more cognitively complex, the opportunity for student empowerment increased. In addition, tasks that required more complex social organization were also more empowering for students.
- Evaluative feedback. Feedback that was presented in private settings as opposed to public settings and feedback that was task-related as opposed to person-related were associated with high levels of student empowerment.

The research indicates that student empowerment fluctuates over time. Although both classrooms experienced varying levels of student empowerment, the ACOT class had a higher average level.

In the ACOT classroom, the four indicators of student empowerment were also related to HCA. The level of student task shaping increased when the level of computer use increased. Larger tasks and complex tasks frequently involved computers directly in their implementation. In addition, the amount of task-

related private feedback increased when students were working with computers.

Therefore, the results of the study indicate that high access to computers promotes an atmosphere that is conducive to student empowerment.

Apple Classrooms of Tommorow
Advanced Technology Group
Apple Computer, Inc.

ACOT Report No. 3

The Influence of High Computer Access on Students' Thinking: First- and Second-Year Findings

by
Robert Tierney
Ohio State University

Background/Problem Statement

This longitudinal investigation was designed to describe the effects of regular in-school and at-home access to computers on students' thinking processes and, in so doing, to confirm or refute anecdotal evidence that computers help students to develop critical thinking skills.

This investigation corrected two major problems associated with most research on the impact of technology in education. First, Apple Classrooms of Tomorrow (ACOT) students in this study had continual access to computers, both in school and at home. To date, most research has been conducted on students who have an average of 15-20 minutes' daily access to a computer. Second, the observations in this study were conducted over a period of two years. Most research lasts less than a year. In this amount of time, it is unrealistic to expect to observe significant changes in the way that students learn or that teachers teach. Moreover, such a short time span is inadequate for researchers to identify and confirm the causes of any changes that do occur.

Study Goal

To examine how high computer access (HCA) supports the development of certain thinking skills, especially critical thinking skills.

Methodology

For two years, the research team has been exploring potential relationships between the computer and writing, thought, and learning. Researchers focused on the thought processes of four tenth-grade students in their first and second years in the HCA classroom and five ninth-grade students in their first year in the HCA environment.

Data collection included: (1) documenting student development over time, (2) observing students' writing behavior to gain insight on their thinking processes, (3) conducting daily interviews with students to probe the nature of their thinking while writing, and (4) conducting periodic interviews with students to obtain perspective on their use of the computer at school and at home.

The data, in the form of videotaped conversations, observational record sheets, and tape-recorded interviews, was logged, transcribed, coded, and analyzed.

Conclusions

The following research findings are a result of investigating the ACOT students' involvement in reading and writing activities.

Ninth-grade (first-year) students

- During the first year of HCA, students' approach to doing research for writing assignments changed from being limited to their own thoughts and teachers' suggestions to using more extended resources and carefully considering how graphics might enhance their work.

- Students demonstrated an expanding repertoire of planning behavior as they considered writing topics. They were more sensitive to their audience, considered a wider range of ideas, and consulted their peers more extensively as the year progressed.

- Handwritten lists as pre-writing activities gave way to more complex mental representations of their ideas. Students tended to give more thought to their ideas both before and after drafting.

- Graphics assumed a significant role in motivating writing and developing ideas. Graphics also enhanced the visualization of thoughts that were difficult for students to express in words.

Tenth-grade (second-year) students

- Over a two-year period with HCA, students' planning strategies were influenced by the flexibility of the computer. Students tended to enter text and graphics directly into the computer; in fact, they used the computer more readily than paper and pencil. Their writing became a fluid process of getting their ideas down and then expanding, developing, and revising them through multiple drafts.

- They used graphics to assist in thinking and developing ideas.

- In year two, students continued to make extensive use of peer input during all stages of the writing process.

- Students' revisions included more substantial changes in year two, including reshaping and reorganizing their texts before printing.

- Students in year two (and also by the end of year one) were self-confident about their technology skills. Many tenth-graders also claimed to be more fluent, better organized, more comfortable, and more capable writers.

EVALUATION OF SCHOOL TECHNOLOGY PROGRAMS

MECC/University of Minnesota Center
for the Study of Educational Technology
Project No. 89-3

At-Home Remediation via Technology: An Exploratory Study of a Computer Loan Program

(formerly **Loaning Computers and Software to At-Risk Students**)

by
Gregory Sales and Jason Earle
College of Education, University of Minnesota

Background/Problem Statement

This study describes a program that allowed students to borrow computers and software. Three factors influenced the nature and timing of this project:

- In 1988, the Minnesota Legislature enacted The Assurance of Mastery (AOM) legislation. This legislation mandates that schools guarantee mastery of minimum competencies in all students. The legislation requires schools to periodically evaluate student skills and provide remedial programs as needed. The legislation does not prescribe strategies or allocate financial resources.

- At the same time that the AOM legislation took effect, Independent School District 279 (ISD 279) was upgrading its computer equipment. This raised the question of how to use the portable Apple //c systems that were operational but no longer met the schools' instructional needs. While newer pieces of instructional software could not be used with the Apple //c, equipment district officials did not want to discard them.

- In addition to complying with AOM legislation and upgrading its computer inventory, ISD 279 was also becoming interested in involving parents in the learning process. This interest was supported by educational researchers and other education experts (Epstin 1988, Lamm 1986, Moles 1982) as a means of improving student performance.

It was proposed that all of these issues could be addressed simultaneously in the project described in this report. In one of the district's schools, students of a sixth-grade class who lacked math competency would be asked to participate in a computer/software loan program that would utilize Apple //c computers and require parent involvement.

Study Goals

The goals of this study were to explore the following issues:

- Could the classroom teacher identify students with mastery deficiencies, match those deficiencies to available software, arrange for students to borrow computers and software, ensure that the equipment was returned, and determine if the students had benefited from the loan?

- Would parents participate in a training program designed to make them aware of their child's involvement in the computer/software loan program and to train them to hook up a loaned computer to their home television set?

- Would students benefit from the loan program? Would they use the prescribed software and would its use help them to attain mastery?

- After involvement in the computer/software loan project, would students, teachers, and other school officials feel positive about the program?

Methodology

The research was conducted on a sixth-grade class at Garden City Elementary School. One teacher is responsible for the math instruction of all students.

Fourteen of the students were identified as deficient in some math skill. These children and their parents were invited to attend a training session to learn how to connect an Apple //c computer to their home television set. Eleven of the 14 parents responded. Of these, ten attended the training session and the eleventh reported already having an Apple computer at home.

This group participated in the project for three months. During this time the five computers and a large assortment of software matched to the students' deficiencies were loaned to students for periods of one week at a time.

Data on the project was collected through observations of the parent training sessions, interviews with students, parents, and the teacher; analysis of the students' self-report work forms; and comparisons of student-reported performance scores with those recorded on the software.

Conclusions

Management of the program was time-consuming. Two tasks—identifying students and matching software to their needs—were relatively easy to accomplish. Two other tasks were more involved than anticipated. Keeping track of who had the computers was difficult and maintaining student disks was time-consuming. Disk maintenance involved the printing of student performance records from the disks and then purging the records from the disks.

To help with disk maintenance, the teacher recruited several students to assist once a week. This was of some help but caused concern for the confidentiality of student performance records.

Parents who participated in the project found the training to be effective and felt their children's participation had been beneficial. Comments from some parents indicated they were involved in and attentive to their children's learning.

Students kept paper records of their use of the software. These records were accurate when compared to the files of student performance that were automatically recorded on the software disks. The records indicated that the students were able to master the skills presented by the software. This mastery was supported by teacher observation.

Observations and interviews yielded a generally positive and supportive attitude toward the project by all parties involved. One area of concern was stated by the math teacher participating in the study. He indicated that some students needed to be "prompted" to take the computer home for additional remedial work after the first week. This may indicate that the novelty of the loan program has a short life with some students.

Recommendations

Based on the study of this project, the following recommendations can be made:

- Computer/software loan programs may be useful in helping students to overcome performance deficiencies.
- Involving parents of academically at-risk students in the remedial process can help to increase student participation.
- Efficient management of a computer/software loan program is vital to the program's success. This task, if done properly, requires more time than a classroom teacher is able to devote. Therefore, management of a loan program should not be added to the duty of the classroom teacher.

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MECC/University of Minnesota Center
for the Study of Educational Technology
Project No. 89-2

A Case Study of a School District's Investigation of Computer-Managed Instruction

by
Jason Earle and Gregory C. Sales
College of Education, University of Minnesota

Background/Problem Statement

Computer-managed instruction (CMI) in education offers promise (Baker 1978; Hofmeister 1984). CMI programs can "encompass educational goals, the curriculum, the instructional model, and an information management system to assist teachers in tracking student progress and scheduling student learning activities" (Fuchs 1988, p. 294).

There are several potential benefits and drawbacks to using CMI (Bluhm 1987). CMI can reduce the time that teachers devote to clerical duties such as scoring and record-keeping so that there is more time for instruction. CMI may enhance the instructional process by quickly and reliably analyzing student performance and providing this information to teachers to help their instructional decision-making. One study (Chapin, as cited in Bluhm, 1987) suggested that CMI promoted positive attitudes among teachers and students. Teachers indicated liking CMI because it allowed them to match students with particular instruction materials. Students indicated that they enjoyed the opportunity to interact with computers.

One concern regarding CMI is its cost-effectiveness. The amount of time that teachers are released from duties such as scoring and recording may not be worth the limited improvements in student achievement. Also, some CMI systems may be misdirected; the objectives emphasized in the software presented by the CMI may not meet the needs of teachers or students in a particular district's educational program.

Besides attending to these concerns when considering CMI, Bluhm (1987) also cautions about the need for schools to carefully plan the implementation of CMI. Bluhm's caution seems well taken, as indicated by research on the implementation of educational innovations (Berman and McLaughlin 1978; Fullan 1982). Unfortunately, there is still not a great deal of information about the *process* of change involved in implementing software such as CMI in schools.

> The vast majority of research on school improvements ignores the specific dynamics of change. Studies that trace change over a period of time (even short periods) are essential to inferring how people change (Fullan 1985, p. 392).

Fullan (1982) and others (Feiman-Nemser & Floden 1986; Olson 1988) have also indicated the importance of understanding the subjective world of the practitioner as it affects the change process.

> An understanding of what reality is *from the point of view of people within the role* [emphasis in the original] is an essential starting point for constructing a practical theory of the meaning and results of change attempts (Fullan, 1982, p. 130).

Study Goals

This study had two major goals. One was to trace the efforts of school personnel at the district and school building level in investigating the use of CMI in the second- and third-grade reading program of an elementary school. The other goal was to enter the subjective world of the media specialist and teachers who were testing CMI to determine how their thoughts and feelings might influence their investigation of CMI.

Methodology

The investigators followed the school personnel investigating the CMI software from the beginning of their preparation in October 1988, through the start of the investigation in January 1989, until the suspension of the investigation in the beginning of March 1989. School personnel involved in the investigation (the media specialist and the four second- and third-grade teachers) kept logs about their thoughts and feelings regarding the CMI and any problems that occurred. In addition they (along with the district project director for technology) were interviewed before, during, and after the investigation. All formal interviews were audio-taped. Field notes were taken of informal interviews and observations. The first author observed teachers during their reading classes once or twice before and during the implementation of the CMI. The first author also observed all planning and formal training sessions as well as the computer lab of each Tuesday and Thursday during January, February, and March. On those occasions when the author was in a reading class, he interviewed the parent volunteers who supervised the computer lab where the CMI was being used. The parent volunteers kept logs of what happened in the computer lab and were also formally interviewed by the first author.

Conclusions

During the investigation period, the CMI software was used in the second- and third-grade teachers' reading classes from 8:45 to 10:30 a.m. on Tuesdays and Thursdays. Students spent 15-20 minutes on those days in the school's computer lab working with reading software managed by the CMI software. Students were supervised while working in the computer lab by a parent volunteer. The media specialist and the teachers agreed that the parent supervision worked well.

The school's media specialist was responsible for training and facilitating the use of the CMI throughout the investigation. In addition, he was required to do a considerable amount of troubleshooting because there were unanticipated problems with the software and its documentation. All this activity by the media specialist took about 50 hours. The media specialist felt that if the CMI software was to be installed permanently he would not be able to devote as much time to it as he had during the investigation. He suggested that the CMI would probably require a system manager who would spend approximately four hours a week managing the system and students' records. The media specialist also indicated that the management part of the CMI made it much easier to individualize the settings on a particular piece of software for large numbers of students.

Teachers adapted well to the change in the usual routine of their reading class. All the teachers noted that the noise level in their rooms was reduced with fewer students in the room; three of the four teachers noted that with fewer students in the room they were better able to focus on the group they were working with. The number of interruptions, however, did seem to increase for a short period of time when students from the computer lab came back into the classroom. Each of the teachers also noted that students were motivated to use the computer.

The teachers were unskilled computer users, and they all experienced frustration and difficulty when attempting to use some of the CMI functions such as printing student reports. Performing these functions took more time than some anticipated or took them away from other teaching activities. The most serious source of frustration for the teachers was that the content presented by the CMI software did not match a large portion of the content from their reading textbooks. It was for this reason that the investigation was eventually suspended in March.

Recommendations

This study suggested several points that schools interested in implementing CMI might want to consider.

- The person in a school or district responsible for identifying and purchasing a CMI system should be in close communication with teachers targeted to use such a system. Teachers appear to have critical information regarding the usefulness of the potential match between a CMI system's content and the content of classroom instruction. Close communications between the purchaser and teachers will help facilitate the identification of an appropriate CMI system for a particular school.

- Because of the complexity of some CMI systems, schools initially may need to budget larger amounts of time for training and implementation than they have for other educational software.

- Schools also need personnel who have the time and ability to manage the system (enter student information, print reports, answer users' questions, and so on). The system manager may be someone other than a teacher or media specialist (whose time might be better spent learning to apply the instructional resources and reporting provided by CMI).

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MECC/University of Minnesota Center
for the Study of Educational Technology
Project No. 89-1

The Current Availability and Use of Computers in Science Education Grades 7-12 in Minnesota

by
Frances Lawrenz and Elizabeth Thornton
College of Education, University of Minnesota, and
Richard Clark
Minnesota Department of Education

Background/Problem Statement

There have been two studies that reflect computer usage in science education. In 1983, a study of science education in Minnesota (Heller 1984) was conducted. That study included the availability of computers to teachers and opinions by principals and teachers about the effects of various factors on the use of computers in science teaching. A 1985-86 national study of science education (Weiss 1987) was conducted that included a section on teacher training in the use of computers as well as the availability of computers and class time using computers.

Study Goals

The purpose of this research was to determine the status of science education in grades 7-12 throughout Minnesota. This report concentrates on data regarding the current availability and use of computers as well as making comparisons with previous studies.

Methodology

The sample design for this survey was developed in the same manner as the previous Minnesota survey (Heller 1984) to represent a cross section of the districts in Minnesota. School districts were divided into six strata, and in each stratum the number of schools selected reflects the percentage of the total students in Minnesota found in that stratum.

Two hundred sixty-six schools were randomly selected, and 547 pre-selected teachers in those schools were sent surveys. The plan called for surveys to be sent to the principal and two teachers from each school. Some schools were selected in both a grade 7-9 and a grade 10-12 category, however; as a result, some schools received questionnaires for one principal and up to four teachers. The selection of teachers provided approximately equal numbers of life science, earth science, physical science, biology, chemistry, and physics teachers.

The letters and questionnaires to the teachers and principal in each school in the sample were sent to the principal for distribution. Three weeks later a telephone

reminder to the principal was made for any questionnaires not returned. Data from the responses has been analyzed using frequency counts and percentages overall as well as according to strata.

Conclusions

Schools in Minnesota have more computers for teacher use than in 1983. The percentage of schools with two to ten computers has gone down, while the percentage of schools with more than ten computers has nearly doubled. The percentage of schools with no or one computer available has remained constant.

Comparison with National Survey

Minnesota teachers can be compared with the 1985-86 national survey of science teachers (Weiss 1987). About the same percentage of Minnesota science teachers see inadequate access to computers as a serious problem as do teachers nationally. Computers are more available for use with science classes in Minnesota than they are nationally. Even though there is some difficulty in accessing computers, 92% of the Minnesota teachers responding report that computers are available, compared to 72% nationally. About 47% of Minnesota science teachers compared with almost 40% of teachers nationally feel that they are at least adequately prepared to use computers. The current survey also shows that Minnesota teachers have had more training in the instructional use of computers than have science teachers nationwide. Although Minnesota science teachers seem more comfortable and better trained and have computers available, they use computers in their classes about the same amount of time within a week as science teachers do nationally. When a comparison is made on overall use of computers, Minnesota science teachers (59%) use computers more than do teachers nationwide (33%).

Comparison with 1983 Minnesota Survey

Overall, computer use in teaching science in Minnesota has increased since 1983. There is an increase in the percentage of teachers using computers at least some of the time and an increase from 6% using computers once a month or more in 1989. Most teachers (64%) still use MECC software (widely available in Minnesota schools) in their science teaching but have increased their use of software from other publishers. Since 1983, many publishers have developed software packages as ancillary materials for their texts. The use of various computer activities in science classes indicates that more than half of the science teachers in the current survey use computers in some way. Minnesota teachers are more interested in using computers for learning (e.g., science content, laboratory tool, drill and practice, simulations) than in extra activities (e.g., games) or very specialized activities for a few students (e.g., writing programs).

Principals and teachers have changed their opinion about what they perceive to be serious problems affecting the use of computers in the science instruction in their schools. Only two factors, the lack of teacher interest in using computers and insufficient numbers of computers, are perceived by principals as more serious in 1989 than in 1983. More than half of the 16 factors surveyed are seen as serious problems by a smaller percentage of principals. This indicates that principals believe teachers are more comfortable with computers now.

The most dramatic changes for principals are in the three factors concerning software. Inadequate numbers of programs, inappropriate software, and a low quality of available science software are seen as serious problems by about half as many principals as in 1983.

Science teachers in Minnesota reported being more comfortable using computers in 1989 than they were in 1983 and were less likely to see a lack of teacher training in how to incorporate computers into science teaching as a serious problem. Of the 16 factors, all but two were seen as serious problems by fewer science teachers in 1989 than in 1983. Fewer science teachers now see insufficient numbers of computers or the lack of technical support as serious problems. The location of computers is less of a problem now than it was in 1983. Fewer teachers see inadequate student cognitive abilities as a serious problem in the use of computers than they did in 1983. Teachers now perceive the numbers and appropriateness of software programs to be less of a problem than in 1983, although their opinion of the quality of available science software has not changed very much in six years.

The factors studied are consistently perceived as more serious problems by teachers than by principals. With only two exceptions, principals and teachers are in agreement that factors that were deemed as serious problems in 1983 are not as serious in 1989. The two exceptions are the principals' opinions that the number of computers and teacher interest in using computers is a slightly more serious problem in 1989.

Recommendations

Since the last Minnesota survey was done in 1983, improvements have been made in almost all areas of computer use in science education. Based on responses to the list of factors in both principal and teacher questionnaires, with only two exceptions, principals and teachers are in agreement that factors that were deemed as serious problems in 1983 are not as serious in 1989. As software is available to be incorporated into existing courses without being simply add-ons, more teachers are likely to use computers in their science instruction.

Principals consistently perceive potential barriers as less serious than do teachers. This difference in perception may itself be a barrier to computer use.

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For a report complete with data tables and charts, please contact the Center.

MECC/University of Minnesota Center
for the Study of Educational Technology
Project No. 89-4

A Report of an Evaluation Study of the Computer Applications Now (CAN) Project

by
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Background/Problem Statement

In the fall of 1988 the Center for the Study of Educational Technology was asked to evaluate a technology-related curriculum innovation that had been designed, developed, and implemented by the St. Francis District (Independent School District #15). The district was interested in obtaining information that would help determine the soundness of the Computer Applications Now (CAN) project and consider its future. Should the project be modified, discontinued, continued in the initial classrooms, or expanded to other classrooms? Meanwhile, the Center wanted to document and disseminate information on the grassroots effort to integrate instructional applications of computer technology in a primary school classroom.

Five factors relating to the effectiveness of program implementation were perceived as being especially relevant for study of the CAN program:

1. The project planning strategy. Project planning strategies that are "collaborative," rather than "top-down" or "grassroots," have been found necessary to both the short-term and long-term success of educational change (Berman and McLaughlin 1978).

2. The participants in the strategy process. Teachers must enter into the planning and implementation of any innovation (Fullan 1982). Their involvement is considered critical for an innovation such as the integration of computers into the elementary classroom (Sheingold et al. 1981). Also, the degree to which change occurs is strongly related to the extent to which teachers cooperate with each other (Fullan 1982).

3. Administrative support given to the project. If teachers are the prime advocators of change, obtaining support of the administration is essential to success (Fullan 1982; House and Lapan 1978). The principal is the most powerful potential source of assistance (Fullan 1982). If administrative support is high, teachers will be more likely to cooperate with each other (Cuban 1986; Fullan 1982).

4. Collegial involvement in the project. Weinshank et al. (1983) reported that collegial involvement, professional contacts, and continuing administrative support are essential to successful implementation of an innovation.

5. School and community relationships. In the elementary school, the most important factor in building a stage for successful change is maintaining a good relationship between the principal, the community, and the teachers (Weinshank et al. 1983).

Study Goals

The questions listed below guided the evaluation of the CAN project.

1. What are the effects of the CAN program on student outcomes such as achievement, attitudes, and time-on-task?

2. How has the CAN program affected teachers?

3. What are the perceptions of District 15 personnel toward the CAN program?

4. What are the perceptions and attitudes of parents toward the CAN program?

5. What is the effect of the CAN program on the instructional environment in the classroom?

Methodology

The Code for Instructional Structure and Student Academic Response (CISSAR) observational system was used to obtain information on instructional content, instructional tasks, classroom structure, and student response in CAN and non-CAN classrooms. Six students were randomly selected from each type of classroom and observed at given time intervals for approximately seven hours over a seven-week period. At the end of all classroom observations, student learning styles were considered by using aspects of the Energic Model of Style and Mediation Ability Theory. This theory defines four types of mediation abilities—perception, ordering, processing, and relating—while the learning style model concerned itself with perception and ordering. The California Aptitude Test (CAT) was also administered to first- and second-graders in both CAN and non-CAN classrooms as a pre- and post-achievement measure.

The Instructional Environment Scale – Revised (IES) was administered to two randomly selected students from each of the five first-grade classrooms to

obtain a qualitative picture of a student's instructional environment. Evaluators used information from a teacher survey, classroom observation, and a student interview to determine the extent to which a statement characterizes instruction for a particular student. A reading specialist and first- and second-grade teachers at the school were also surveyed and interviewed. The purposes of the survey and interviews were to obtain information on teacher computer experience and attitudes in general, and to focus on teachers' perceptions of and attitudes toward the CAN program.

Interviews were also conducted with the principal and four central office personnel. The interviews provided information about the design, development, implementation, and evaluation of the CAN program. Parents were surveyed through a two-cluster, ten-item questionnaire. The first cluster focused on perceptions of the quality of the CAN project and the second cluster on parental attitudes toward computers in general. The hardware and software review was based on the CAN Software Catalog 1987-88, student observations, and an interview with one of the CAN teachers. The hardware review focused on the physical layout of the computers and the appropriateness of the equipment for an elementary classroom. The software review focused on the appropriateness of the software for first-graders and the variety of software used.

Conclusions

Several findings can be reported regarding the effects of the CAN program on student outcomes.

- There was a significant difference between CAN and non-CAN classrooms in proportion of total time spent on primary academic activities (reading, mathematics, spelling, handwriting), but not in total time spent on total academic activities (primary activities plus independent study and other academic activities).

- In the CAN classrooms more academic time was spent on paper tasks and computer/other media tasks and less time on teacher tasks (lecture, teacher-student discussions).

- There was a significant difference in the two classrooms in proportion of academic time spent in an entire group structure and small group structure, but not in individual instruction.

- The instructional environment in the two types of classrooms differed only in that there was less opportunity for student practice in non-CAN classrooms.

- There was also a significant difference in CAN and non-CAN student responses during non-academic time.

- The perceptions and attitudes of teachers and other district personnel were strongly influenced by a general lack of communication

regarding the CAN project, and the lack of a carefully planned process in establishing and carrying out the project contributed to these communication difficulties.

- Parent reaction to the CAN program was mixed.

It is the conclusion of the evaluation team that the most relevant findings of the study do not pertain to student learning or the classroom environment. Rather, a flawed process—or even the absence of a carefully planned process—in the development and implementation of the CAN project resulted in problems that had nothing to do with the innovation itself. The evaluation team concludes that nothing in the results of the evaluation warrants the discontinuance of the CAN project, nor were there results that would clearly support the expansion of the project under the present circumstances.

Recommendations

The evaluation team makes a conditional recommendation for the continuation or expansion of the CAN project. There is serious need for the district to give formal and informal support to the project. Lines of communication must be opened across the district between CAN and non-CAN teachers. Interest among non-CAN teachers should be encouraged through greater efforts to communicate about the project and to allow teachers to generate other options for integrating computers into the classroom. Resources must be provided for direct support of the program as well as for staff development activities.

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THE DESIGN AND USE OF TECHNOLOGY-RELATED PRODUCTS

MECC/University of Minnesota Center
for the Study of Educational Technology
Project No. 89-5

Frequency and Spacing of Drill and Practice in the Learning of Verbal Information Using a Computer-Based Drill

by
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Background/Problem Statement

Since computers entered the educational realm, drill-and-practice programs have been used widely (Gerlach 1984; Siegel and Misselt 1984; Davidson and Traylor 1987). Overall, computer-based instruction has spurred research throughout the field of instruction (Kearsley, Hunter, and Seidel 1983). Characteristics of learners and how they affect the learning process are being studied. For drill-and-practice programs, aspects of individualization are accomplished through processes such as feedback, correction of errors, varying levels of difficulty, and maintenance of individual student records.

The question of when to reintroduce a missed item during a drill before it is removed from short-term memory has been studied. Goldenberg (1987) found it to be after two intervening items, with the second recommended position being after three items. Regarding spacing and number of review sessions, Peterson, Ellis, Toohill, and Kloess (1935) showed that a second review was more effective than the first. Gay (1973) found that an early review (near the time of original learning) and a late review (near the retention measure) are better than two early or two late reviews. She also concluded that any pattern is better than no review.

Study Goals

This study was designed to further clarify the optimal frequency and spacing of drills in the learning of verbal information.

The many student differences which can affect success in various learning strategies can make it difficult to come to clear-cut conclusions regarding aspects of computer-based instruction. Tobias (1981), in a discussion of adapting instruction to individual differences among students, suggests that research might begin by observing what various students actually do and what instructional options they select. From this observation, the researcher can then generate a prediction as to what strategy might best promote learning.

This study is being carried out in two phases. Phase One, which is nearly completed, tracked students' unrestricted use of a computer-based drill, recording the timing, length, and activity of each practice session. A study of the

resulting data will precede Phase Two, the development and testing of a drill-and-practice schedule.

Methodology

A total of 62 fourth-, fifth-, and sixth-grade students in an urban Minneapolis public elementary school participated in this study. The students were not randomly selected from the general population and the study was limited by two major factors: (1) Several students were absent during the study due to the flu and (2) limitations in the number of computers led to less use of the drill than expected.

In order to observe whether better choices (leading to better success) would be made by students of high ability, scores of the California Aptitude Test (CAT) exams taken in the fall of 1988 were used as a measure of ability.

The computer-based drill developed for use in this study was the naming of the capitals of the 50 states of the United States. In order to provide an optimal practice tool, the findings of research regarding discrimination feedback (Siegel and Misselt 1984) and review of missed items (Goldenberg 1987; Salisbury 1985) were incorporated into the drill. The computer recorded each practice so that the student could stop at any time and continue at the next practice session.

The study encompassed a two-week period. At the beginning of the first week, the material was assigned and a written pretest was given. The computer-based drill was demonstrated and explained to the students. The choices of when and how often to practice were left completely to the students. Each student had a disk copy of the drill program and a piece of paper to use as a backup to the information recorded by the computer. On the paper, the student recorded the results (number of tries, number correct, number remaining) on blanks arranged according to the date of the practice. At the end of the two weeks, a final written test was given.

Conclusions

Fifty-one of the students (82%) participated in all three parts of the study: pretest, use of drill, and final test. Twenty-two of these learned 60% or more of their unknown items, and 29 learned 38% or fewer. Since the goal for the students was to learn all the capitals, the 22 were considered "successful" (S) and the others were considered "unsuccessful" (U). The S group practiced more times, completed the drill more times, and practiced more items than the unsuccessful group. Also, more members of the S group practiced both weeks and/or practiced later in the two-week period. One variable did *not* differ significantly between groups, and that is the number of items practiced per each item learned. This suggests that it may be possible to quantify the amount of practice needed in order to learn an item.

Results suggest that ability level (as provided through the math/reading CAT scores) was not strongly correlated to the choices made by the students as to when and how often to practice. Success was correlated more with the number of repetitions of the drill than with either number of items tried or practice time.

The findings of Phase One agree with previous research (Gay 1973; Peterson, Ellis, Toohill, and Kloos 1935) regarding the time of practice. The 23 students who practiced both weeks (both "early" and "late") learned an average of 65% of unknown items. The 14 students who practiced only late learned an average of 36%, while the 12 who practiced only early learned an average of 19%. None of the students considered "successful" practiced only during Monday through Wednesday of the first week, and none of the 11 students with a success rate of less than 10% practiced both weeks or at the end of the second week.

Recommendations

The results show clearly that to learn verbal information, a student should complete the drill at least once. Since those who practiced both early and late in the two-week period were more successful, at least two practice sessions should be scheduled accordingly. The ratio of number of items practiced to the number of items learned may be the principal statistic that will allow for a further determination of the number of practices needed.

Further analysis of this data will be made before a schedule of practice will be determined and tested in Phase Two. The analysis will involve the effect of the pretest score on the results, and an item-by-item analysis studying the relationships between pretest knowledge, practice, and final test knowledge.

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ADDITIONAL RESOURCES ON RESEARCH IN EDUCATIONAL TECHNOLOGY

These resources are selected because of the comprehensiveness of their coverage of research trends and their timeliness of publication.

Becker, H. (1988). *The impact of computer use on children's learning: What research has shown and what it has not.* Baltimore, MD: Center for Research on Elementary and Middle Schools, The Johns Hopkins University.

Office of Technology Assessment, U.S. Congress (1988). *Power On! New Tools for Teaching and Learning.* Washington DC: U.S. Government Printing Office.

Olson, J. (1988). *School Words/Microworlds: Computers and the Culture of The Classroom.* New York: Pergamon Press.

Roblyer, M.D. (1989). The effectiveness of microcomputers in education: A review of the research from 1980-1987. *T.H.E. Journal* (16)2, 85-89.

Roblyer, M., Castine, W., and King, F. (1988). *The Effectiveness of Computer Application for Instruction: A Review of Recent Research Findings.* New York: The Haworth Press.

MANUSCRIPT SPECIFICATIONS

The MECC/University of Minnesota Center is interested in reporting the research results of educational practitioners and researchers from other institutions. Manuscripts should be typed, double-spaced, on one side of an 8-1/2" by 11" sheet of paper, with uniform margins. The authors' name, professional title and affiliation, address, and phone number should appear on a separate sheet of paper. Manuscripts should conform to the following guidelines.

Description

The manuscript should be viewed as an expanded abstract. It should include a background/problem statement, study goals, methodology, conclusions, and recommendations. A description of each section follows. The abstracts are published in the Center's research bulletin, which is currently published twice a year and is available for $12.95 by writing to the Center. The bulletin has a diverse readership, including university faculty, staff development personnel, computer coordinators, and teachers. While the research bulletin is more technical than popular computing magazines, authors should write for a diverse audience with different levels of expertise with educational research. A good rule of thumb when writing manuscripts is to view the research bulletin as an intermediate step between the non-technical article and an article appearing in a scholary journal.

Background/Problem Statement

This section describes and defines the question or problem and provides background information. This includes the importance or significance of the project, identification of audiences that may find project results useful, working definitions, and limitations of the study. When possible, validate the problem definition with supporting citations.

Study Goals

This section briefly describes study goals or hypotheses.

Methodology

This section contains descriptions of the sample, research design, and measurement used. The population from which the sample was drawn and the method of selecting the sample should be detailed in the sample description. A short description of the educational environment in which the project took place is highly desirable. Details of the research design should include identification of the type of research design and review of the steps taken to collect data, including any that may have influenced the results.

Conclusions

This section briefly describes research results.

Recommendations

The emphasis in this section should be on the identification and interpretation of the major findings. When possible, discuss why the results may have occurred, fit them into findings of previous research, suggest field applications, and make theoretical interpretations (Borg and Gall, 1983). The Center is especially interested in how research results affect classroom use of technology.

Please follow the American Psychological Association (APA) format in setting up the references section of the paper.

References

Borg, W., and Gall, M. (1983). *Educational Research: An Introduction (4th ed.).* New York: Longman.